Some properties of bones at different nanostructural microstrucral and mesostructural levels.

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Abstract

The norm of elastic constant tensor and the norms of the irreducible parts of the elastic constants of bones at different nanostructural, microstrucral and mesostructural levels are calculated. The relation of the scalar parts norm and the other parts norms and the anisotropy of bones at different nanostructural, microstrucral and mesostructural levels are presented. The norm ratios are used to study anisotropy of bones at different nanostructural, microstrucral and mesostructural levels and the relationship of their structural properties and other properties with their anisotropy are given.

Keywords: Mineralized collagen, Microfibril, Fibril, Fiber, Lamella, Canaliculi, Lacunae, Osteous, Cortical bone Nanostructrctural level, Nanostructrctural level, Mesostructural level, Norm, Anisotropy, Elastic constants.

Accepted on March 14, 2018

Introduction

The decomposition procedure and the decomposition (Elastic constant tensor can be decomposed into two scalar parts, two deviator parts and one nonor part) of elastic constant tensor is given [1,2] also the definition of norm concept and the norm ratios and the relationship between the anisotropy and the norm ratios are given [1,2]. As the ratio (Norm of the scalar part of the elastic constant tensor/Norm of the elastic constant tensor) becomes close to one the material becomes more isotropic, and as the ratio (Norm of the nonor part of the elastic constant tensor/Norm of the elastic constant tensor) becomes close to one the material becomes more anisotropic is explained [1,2].

Calculations

By using and the decomposition of the elastic constant tensor, we have calculated the norms and the norm ratios as shown in Tables 1 and 2.

Results and Conclusion

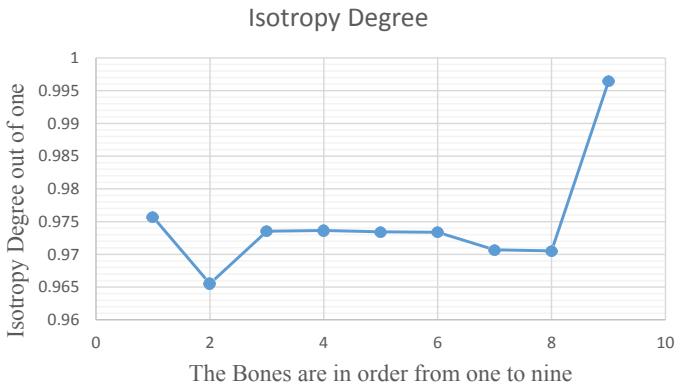
From Table 2 and the Graphs 1-3 and analysing the ratio $\frac{N_s}{N}$ we can conclude that Cortical bone, mesostructural level is the most isotropic bone which has the largest value (0.99643) and has the smallest value of $\frac{N_n}{N}$, (0.03629) and small value of $\frac{N_d}{N}$,

Table 1. *Elastic constants (GPa) [3].*

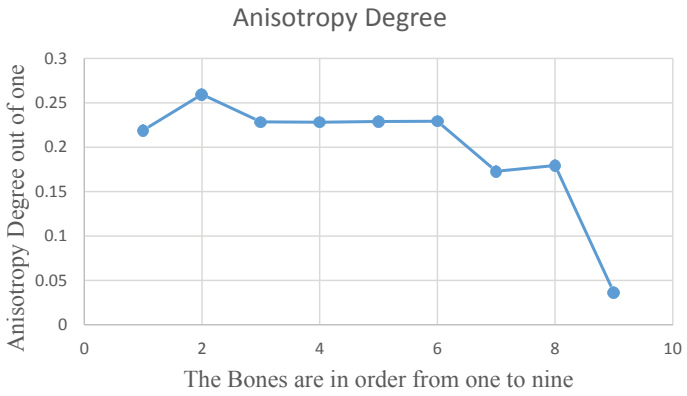
Bone	C_{11}	C_{22}	C_{22}	C_{12}	C_{13}	C_{23}	C_{44}	C_{55}	C_{66}
Mineralized collagen, microfibril, Nanostructrctural level	1.070	1.070	1.070	0.434	0.434	0.434	0.632	0.632	0.632
Mineralized collagen, fibril, Nanostructrctural level	1.133	1.185	1.226	0.468	0.468	0.474	0.787	0.787	0.787
Mineralized collagen, fiber, Nanostructrctural level	16.144	16.144	16.110	6.233	6.233	6.237	9.928	9.928	9.928
Lamella, microstrucral level	16.08	16.08	16.07	6.21	6.21	6.22	9.88	9.88	9.88
Lamellae with canaliculi, microstrucral level	16.18	16.18	16.14	6.24	6.24	6.25	9.96	9.96	9.96
LRC Lamellae, microstrucral level	21.57	21.57	21.51	8.32	8.32	8.33	13.28	13.28	13.30
Lamellae with lacunae, microstrucral level	19.44	20.34	32.2	8.24	8.25	8.25	14.02	12.33	12.54
Osteous, mesostructural level	19.44	20.34	32.3	8.24	8.25	8.25	13.17	13.16	13.18
Cortical bone, mesostructural level	21.96	23.00	26.04	8.24	10.19	8.25	6.89	6.12	6.45

Table 2. *The norms and norm ratios.*

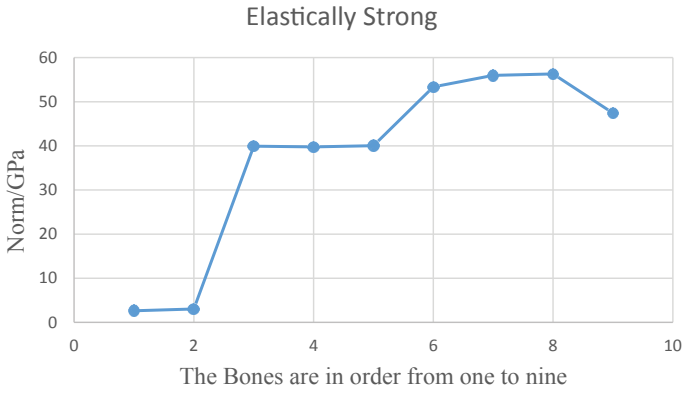
Bone	N_s	N_d	N_n	N	N_S/N	N_d/N	N_n/N
Mineralized collagen, microfibril, Nanostructrctural level	2.56451	0	0.57557	2.62830	0.97573	0	0.21899
Mineralized collagen, fibril, Nanostructrctural level	2.94165	0.06102	0.79082	3.04671	0.96552	0.02003	0.25956
Mineralized collagen, fiber, Nanostructrctural level	38.8703	0.02427	9.12636	39.9273	0.97353	0.00061	0.22857
Lamella, microstrucral level	38.7178	0.01024	9.07045	39.7661	0.97364	0.00026	0.22810
Lamellae with canaliculi, microstrucral level	38.9629	0.02862	9.16211	40.0257	0.97345	0.00072	0.22891
LRC Lamellae, microstrucral level	51.9518	0.05348	12.2324	53.3725	0.97338	0.00100	0.22919
Lamellae with lacunae, microstrucral level	54.3382	9.34852	9.67607	55.9791	0.97069	0.167	0.17285
Osteous, mesostructural level	54.65294	9.05628	10.10629	56.31249	0.97053	0.16082	0.17947
Cortical bone, mesostructural level	47.26546	3.61626	1.72146	47.43485	0.99643	0.07624	0.03629



Graph 1. *Isotropy degree.*



Graph 2. *Anisotropy degree.*



Graph 3. *Elastically strong.*

(0.07624) and Mineralized collagen, fibril, Nanostructrctural level is the least isotropic bone which has the smallest value (0.96552) of $\frac{N_n}{N}$ and has the largest value (0.25956) of $\frac{N_n}{N}$ and has large value (0.02003) of $\frac{N_d}{N}$, so we can say that Mineralized collagen, fibril, Nanostructrctural level is the most anisotropic bone. Also we can make the comparison in the same structural level, in the case of Nanostructrctural level the most isotropic bone is Mineralized collagen, microfibril, and the most anisotropic bone is Mineralized collagen, fibril, and in the case of microstrucral level, the most isotropic bone is Lamella, and Lamellae with lacunae is the most anisotropic bone, and in the case of mesostructural level the most isotropic bone is Cortical bone and the most anisotropic bone is Osteous.

Also we can notice by considering the value of N that this value is the highest (56.31249) in the case of Osteous, mesostructural level so we can say that Osteous, mesostructural level elastically is the strongest bone, and the in the case Mineralized collagen, microfibril, Nanostructrctural level (2.62830) which is its value of N is the smallest so we can say that Mineralized collagen, microfibril, Nanostructrctural level elastically is the least strong bone among the bones in the table.

References

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